ISB 121: METHODS AND ASSESSMENT IN INTEGRATED SCIENCE – 3 CREDITS

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Science Process Skills

- Planning
- Designing an experiment
- Observing
- Manipulating
- Measuring
- Analysing
- Classifying
- Generalising
- Communicating results

Technology to aid science learning

- Visual aids
- Audio aids
- Audio-visual

LEARNING THEORIES

- Behaviorist approach to learning
- Constructivist approach to learning

Behaviorist approach to learning

- Initial psychology - observed human behaviour – what one says and/or does
- No account taken of internal conditions such as mental or cognitive behaviour of humans
- Examples of human behaviour: Reaction to external stimuli or an internal stimuli

Some behavioral psychologists - 1

- John Watson (1930s)– considered father of behaviorist school of psychology
- Advocated study of observable human behaviour – this he considered objective and not subjective
- Considered internal conditions or variables of organisms as subjective
- Learning was the performing of a behaviour

Some behavioral psychologists-2

- Pavlov- advocated classical conditioning
- Experimented on dogs and noticed they drooled (salivated) at the sight of food or sound of his approach
- Animal learnt new stimuli and linked them to cues to perform a reflex action
- Neutral stimulus – Pavlov rang a bell and the dogs did not drool
- Unconditioned stimulus (food) – the dogs would salivate(unconditioned response)

Pavlov’s dogs

- Classical conditioning – repeated ringing of bell and the dogs would salivate
- Bell – conditioned stimulus
- Salivating – conditioned response
- Neutral stimulus – does not attract a response

Thorndike’s Instrumental or operant conditioning

- Cat in a puzzle-box
- Cat struggles, bites, chews etc. to get out
- May succeed to get if it bites of the cord securing the gate
- Trial-and-error learning
- Several trial lead to success
- Unsuccessful attempts may be eliminated
- The animal learnt to associate stimulus (restriction) with response (impulses)

Thorndike’s law of effect

- Any act in a given situation that produces satisfaction becomes associated with the situation
- Only the fittest responses shall survive
- Some reinforcers are learnt (e.g. release from the cage in this example)

Skinner’s operant conditioning

- Based on the idea that learning is a function of overt (seen) behaviour
- Change in behaviour occurs as a result of response to events (stimuli)
- Stimulus-Response which is reinforced (rewarded) conditions the individual to respond
- Reinforcement is key to Skinners’ Stimulus-Response theory
- Negative reinforcers may result in reduced response

Application of behavioral theory

- In teaching
- Classroom management
- Behaviour modification of individual students
- Instructional programmes
- Programmed instruction [providing practice questions (stimuli) and answers (responses) to gradually promote students' understanding
- Student responds and receives immediate feedback

- Difficulty level increases gradually (positive reinforcement)

- Good performance rewarded with praises, prizes, good marks etc. (secondary reinforcers)

Principles of operant learning

- Behaviour that is positively reinforced will reoccur
- Information should be presented in small amounts so that responses can be reinforced
- Stimuli generalisation: Reinforcement will generalise across similar stimuli producing secondary conditioning

Other areas of application

- Individual instruction: Programme of instruction designed to suit the individual learner
- Mastery learning: An instructional approach designed by Bloom to provide opportunities for the learner to reach a specified level of mastery (e. g. 80% correct). This includes clear objectives and performance standards, teaching, testing, reteaching and retesting

Other areas of application - 2

- Computer-aided instruction: Use of computer to work through programmed learning materials
- Computer-managed instruction: a computer system that both directs the learner through learning modules and keeps track of the performance

Constructivist approach to learning

- Cognitive approach:
- Learning is acquisition or re-organisation of cognitive structures
- Learners process and store information
- Learners are active perceivers
- Learners are discoverers of knowledge

Strategies used for cognitive learning

- Observation
- Modelling
- Self-instruction

Piaget' concept of learning

Learning consists of acquisition of information and modification of schemas

- Schema – category of knowledge and the process of obtaining that knowledge. It describes both the mental and physical actions that the learner takes in understanding and knowing (e. g. modification of what one is familiar with)

Piaget's concept of learning

- Assimilation – process of taking in new information into previously existing schema (e.g. one may add to the existing schema further details. A small cow may be known to a child for a long time before the realises that big cows do exist)
- Accommodation-Changing the existing schemas as a result of new information obtained and/or developing new schema
- Equilibration – All children strike a balance between assimilation and accommodation. This describes how children move from one stage of cognitive development to another

Piaget's stages of cognitive development

- The Sensorimotor stage:

The six sub-stages are:

- **Reflexes** (0 – 1 month) – the child understands the environment through reflex actions (e.g. sucking, looking etc.)
- **Primary circular reactions** (1 – 4 months): Coordinating sensation and new schemas (e. g. sucking the thumb, involuntarily and then repeated later due to the satisfaction

- **Secondary circular reactions** (4 – 8 months): The child focuses and intentionally repeats some actions to attract attention or satisfy some needs (e. g. picks toys and put in mouth or makes some regular noise)
- **Coordination of reactions** (8 -12 months): Actions much more intentional and some imitations of observed behaviour occur while child recognises some objects (e.g. when the toy is shaken it will rattle)
- **Tertiary circular reactions** (12 – 18 months): Develop trial and error activities (e. g. mimicking different sounds)
- **Early representation of thought** (18 -24 months): Develop symbols to represent events or objects and children begin to understand the world through mental operations rather than through actions (e. g. clapping to express joy/ some thought processes)

Preoperational stage (2 – 6 years)

- Though language development starts children do not understand logic or mentally handle information
- **Egocentrism**: Inability to adopt views of others – stick to their own views.
- **Lack of conservation:** Unable to understand conservation of number, length, mass, weight, volume and quantity (e.g. equal quantity poured into different containers may not be recognised by children at this stage)

Concrete operational stage (7 – 11 years)

- Begin thinking logically about concrete events but may not understand abstract or hypothetical concepts
- **Logic**: Children fairly good at use of inductive logic (e.g. Generalise an experience; may not be able to deduce that to dissolve a substance it must be soluble). Deductive reasoning at this stage may pose a problem.
- **Reversibility**: Children become aware that events can be reversed (e.g. An insect is animal and that an example of an animal is an insect)

Formal operational stage (12 years to adulthood)

- Ability to think about abstract concepts. Development of logical thought, deductive reasoning, systematic planning
- **Logic**: Deductive logic emerges – general principles are used to determine specific outcomes
- **Abstract thinking**: Consequences of actions taken are considered thus long term planning skills are developed
- **Problem-solving**: Systematically solve problems; methodical and logical procedures used

Ausubel and meaningful learning

- In contrast to rote leaning
- New knowledge must be related to existing knowledge
- Rote learning: Arbitrary, verbatim, non-substantive incorporation of new knowledge into cognitive structure; No effort to integrate new knowledge with existing concepts in cognitive structure; What is learnt is not related to experience with other events; No affective commitment to relate new knowledge to prior learning

Meaningful earning

- Non-artbitrary, non-verbatim, substantive incorporation of new knowledge into cognitive structure
- Deliberate effort to link new knowledge with higher order concepts in cognitive structure
- Learning related to experiences with events
- Affective commitment to relate new knowledge to prior knowledge

Stages of Ausubel's model of learning

- **Stage 1 - Advance organiser**
- Clarify the aim of the lesson
- Present the organiser
- Relate organiser to students' knowledge
- **Stage 2 – Presentation of learning task/material**
- Make the organisation of the new material explicit
- Make logical order of learning material explicit
- Present material and engage students in meaningful learning activities
- **Stage 3 – Strengthen cognitive organisation**
- Relate new information to advance organiser
- Promote active reception learning

How individuals learn - Ausubel

- Learning is based on the representational and combinatorial processes when the information or lesson is presented
- Subsumption: a learning process in which new material is related to relevant ideas in the existing cognitive structure
- On forgets because certain details get integrated and lose their individual identity
- Ausubel’s theory emphasises that subsumption involves reorganisation of existing cognitive structures and the development of new structures

Application of Ausubel's theory

- The theory applies only to reception (expository) learning in educational settings
- Ausubel's reception learning is different from rote learning (which does not involve subsumption – i.e. Use of meaningful materials)
- Ausubel's reception learning is also different from discovery learning (where the learner must discover information through problem-solving)

Bruner and discovery learning

- The goals of education are to free society and to assist students in developing their full potential
- To instruct students on how to use tools (esp. language, instruments and the technologies) at their disposal to amplify and express their own powers
- For students to experience cognitive and intellectual mastery

Brunner and learning

- Learning is an active, social process in which students construct new ideas or concepts based on their current knowledge. The student selects the information, forms hypothesis and then integrates this new material into their own existing knowledge and mental constructs

Brunner's three stages of learning

- **Enactive**: Children have to experience the concrete material (manipulating and touching real objects) in order to understand
- **Iconic**: Learners are able to represent materials graphically or mentally (e.g. Do basic addition problems mentally)
- **Symbolic**: Learners use logic, higher order thinking skills and symbols systems (e. g. formulae)

Acquisition of knowledge - Brunner

- Knowledge and skills are not acquired gradually but in a staircase pattern which consists of sudden increases and rests
- These steps are not linked to age but to the environment
- Knowledge is best acquired when students are allowed to discover it by themselves
- Knowledge can be acquired at any developmental stage provided it is appropriately organised (unlike Piaget who ascribes developmental stages)

Von Glasersfeld and radical constructivism

- Knowledge and reality do not have absolute value
- Reality is made up of the network of things and relationships that we rely on in our living and which believe in and others also believe in
- Learners interpret and construct reality based on their experiences and interactions with the environment

Von Glasersfeld's thinking

- Instead of truth one should think of viability
- Concepts, models, theories etc. are viable if they explain adequately the contexts in which they are used
- Objectivism ⟷ Constructivism
- Glasersfeld's thinking has been influenced by Piaget's theory of

Radical constructivism

- Because it breaks with conventional theory of knowledge
- Knowledge does not represent an objective reality
- Knowledge is ordering and organisation of a world consisting of our experience
- Knowledge is received either through our senses or by way of communication

Different types of constructivism

- Radical
- Social
- Physical
- Evolutionary
- Postmodern
- Social constructionism
- Information processing
- Cybernetic system

Application to education - 1

- Despite the many views about constructivism, proponents are unanimous about how it should affect education
- Many constructivists believe that the theory holds a promise for solutions to the predicaments of our schools system

Application to education - 2

- The teacher provides opportunities and incentives for students to build up knowledge
- Teachers are guides, coordinators, facilitators, resource advisors and coaches
- Learners are sense makers
- Teachers listen and diagnose ways in which what is learnt is interpreted
- Teacher uses this feedback to inform further action

Application to education - 3

- Learning requires self-regulation

- Learning requires building of conceptual structures through reflection and abstraction (i.e. concept development and deep understanding)

Application to education - 4

- Learning emphasises the process and not the product
- Students' errors are seen in positive light
- The errors are indication of how they are constructing knowledge from their experiences

Characteristics of Constructivist teaching and learning

- Multiple perspectives and representation of concepts are encouraged
- Goals and objectives are derived by student or negotiated with teacher
- Teacher provides opportunities or activities to encourage metacognition, self-regulation, self-analysis, reflection and awareness

Characteristics-2

- Authentic learning environments, situations, skills, contents and tasks should be provided

- Teacher encourages knowledge construction and not reproduction

Characteristics - 3

- Teacher considers the previous knowledge constructions, beliefs and attitudes in the knowledge construction
- Emphasise problem-solving, higher-order thinking skills and deep understanding

Characteristics - 4

- Encourage exploration by students

- Scaffold tasks, skills and knowledge acquisition

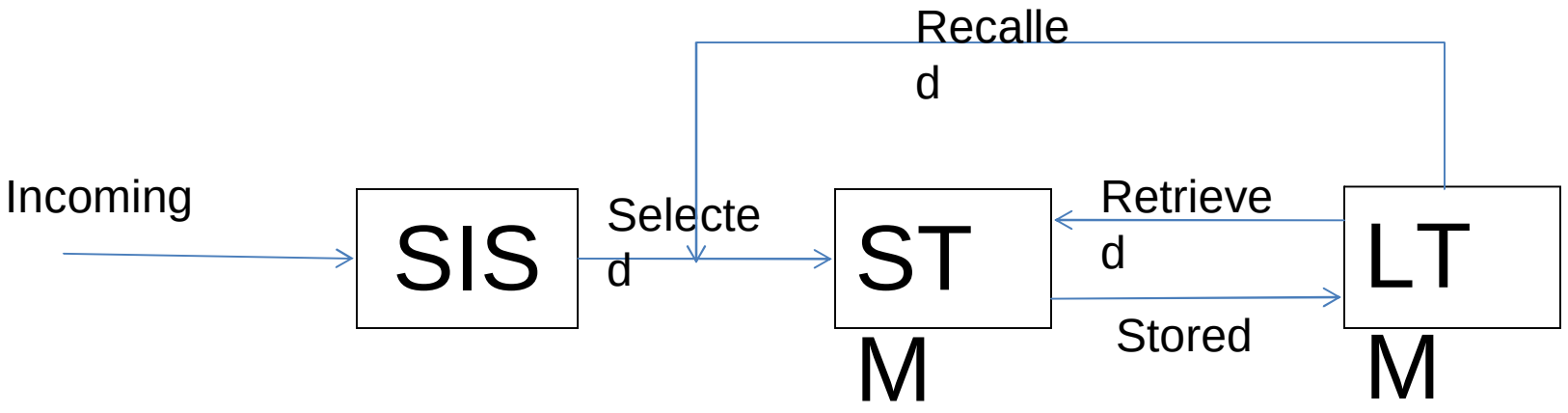
Characteristics - 5

- Collaborative and cooperative learning encouraged
- Assessment is interwoven with teaching

The Generative Learning Model

- Proponents:
  - Osborne
  - Wittrock
  - Cosgrove

Schematic diagram of the model



SIS – Sensory Information System

STM – Short Term Memory

LTM – Long Term Memory

Cosgrove and Osborne (1985)

- Identified four stages of instruction:

1. Preliminary stage

2. Focus stage

3. Challenge stage

4. Application stage

Preliminary stage

- During lesson preparation teacher takes account of students' previous knowledge about the topic

- Students' p. k. are classified as scientific and non-scientific

Preliminary stage (contn’d.)

- Questions may be used to determine students’ concepts or alternate conceptions

- Students are encouraged to talk or demonstrate their previous knowledge about the topic

Focus stage

- Teacher provides context for the lesson at this stage

- Teacher provides activities that would help students to discuss the topic

Focus stage (contn’d.)

- Students are encouraged to actively participate

- Students may engage in group work or collaborative work

Challenge stage

- Teacher encourages open discussion
- Students express their individual views
- Teacher allows all views to be expressed

Challenge stage (contn’d.)

- Later teacher presents scientific view
- Teacher allows students to compare their views with scientific view
- Students reconstruct knowledge by coming out with meaning of the concept being learnt

Application stage

- Teacher provides problems that students solve
- Students use the scientific method to solve the problems

The FIVE Es Instructional model

This is an instructional model that comprises five Es:

- Engage
- Explore
- Explain
- Elaborate
- Evaluate

Engage stage

- Represent the material in a form that is meaningful, familiar and relevant to students
- Re-represent for greater understanding
- Diagnose students' problems (Diagnostic assessment)

Explore stage

- Teacher provides opportunity for students interact with the teaching materials
- Students say what they know about the materials
- Students perform some activities

Explain stage

- Teacher presents the scientific view
- Students views are matched with the scientific view
- Students re-organise their views
- Students discuss for understanding
- Formative assessment occurs at this stage

Elaborate

- Further examples are provided by teacher
- Students are called to express more of their views (more scientific views emerge)
- Summative assessment may be done at this stage

Evaluate stage

- Another stage for summative assessment
- Tasks are used to assess students understanding of concepts
- Students engaged in activities that test their science concept formation

LESSON NOTES PREPARATION

- At the beginning of each school term plan the order in which you will teach topics listed in the Teaching Syllabus for Natural Science - P1 – P3/Teaching Syllabus for Integrated Science-Primary 4 – 6/Teaching Syllabus for Integrated Science – Junior High School for the term

- Plan a **Scheme of Work** which comprises what goes into each week’s lessons

- Begin to write your lesson notes

Structure and organisation of the syllabus

• Section	Primary 1
• Diversity of Matter	Unit 1:Living and non-living things
	Unit 2:Measurement (length, mass, volume and time)
• Cycles	Unit 1: Sun and Earth
	Unit 2: Day and night

Scheme of work

- Week Topic Activity

  1 Sun Observation/Drawing

  Sky Counting stars/Drawing

  2 Earth Observation/Drawing

  Day and night Tell day time/night time

General objectives

The pupil will:

1. Recognise that there are repeated patterns of change in nature and understand how these patterns arise
2. Show awareness of the cyclic nature of day and night
3. Recognise that the sun is the driving force behind many cyclic events and processes in nature

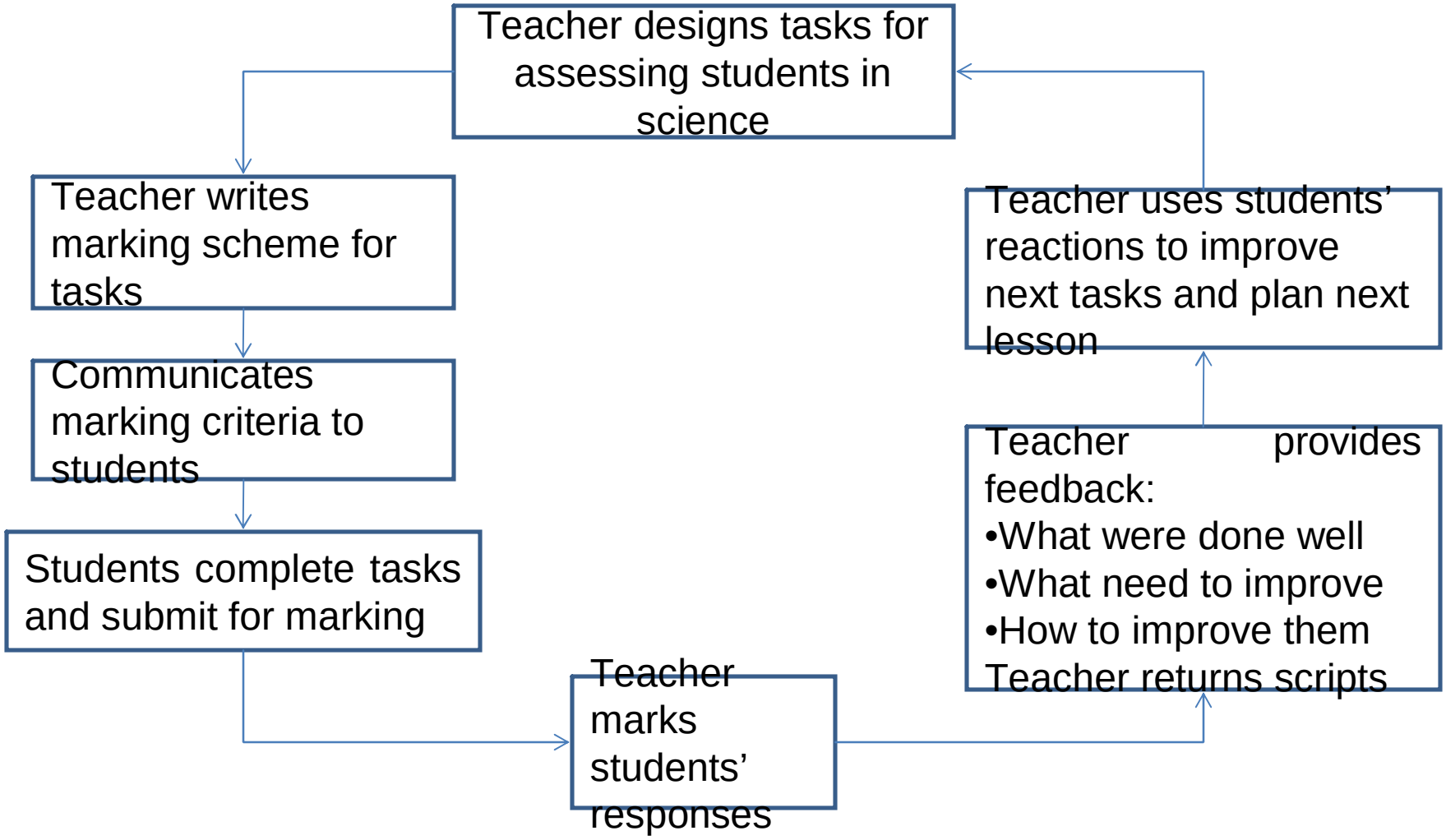
Topic: The Sun

Specific objectives

Pupils would be able to:

1. observe the sun and describe its shape
2. draw the round shape of the sun
3. tell their feeling of the sun blinding them
4. describe the sun as full of light
5. describe how the sun changes its position in the sky

A Flow Chart for implementing effective continuous assessment



Marking criteria

- Marking criteria are the same as ‘Scoring guides or Rubrics’
- They tell about how marking would be done and acceptable presentation of solutions
- They also tell about how many marks each point carries

Marking keys

- Marking keys are the same as ‘marking schemes’
- They depict acceptable solutions to the tasks
- They show how many marks each acceptable solution carries
- They are solely for the teachers’ use and may be used with students when marked scripts are being worked through

Purposes of assessment

- Diagnostic purposes
- Formative purposes
- Summative purposes

Diagnostic assessment

- Determine students' learning difficulties
- What needs improvement?
- For example, Are they able to articulate clearly their thoughts? Are they able to express their thoughts, arguments, and ideas clearly and effectively ?

Formative assessment

- How will students improve what needs improvement (i.e. their learning difficulties)?
- Regular and relevant feedback written on students' tasks
- Discussion of feedback
- Providing appropriate reference materials for students

Summative assessment

- How much have students mastered (known) out of the materials taught?
- Are students able to exhibit some specified skills?

Assessment FOR learning and Assessment OF learning

- Diagnostic and Formative assessments are assessments FOR learning. They help students to enhance learning and learning output

- Summative assessments are assessments OF learning. They determine how much students have learnt

- Continuous assessment should be assessment FOR learning